

TAXONOMIC STATUS OF CLAYTONIA ROSEA AND C. LANCEOLATA (PORTULACACEAE)¹

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ABSTRACT

Claytonia rosea Rydb., not currently recognized in the Rocky Mountains, is separable from *C. lanceolata* Pursh by gross morphological, karyological and ecological characters.

Claytonia rosea Rydb. is a species not currently recognized in the Rocky Mountains, and is usually synonymized under *C. lanceolata* Pursh (cf. Harrington, 1954; Weber, 1953). In Arizona *C. rosea* is accepted with the reservation that it may not be distinct from *C. lanceolata* (Kearney & Peebles, 1951). Davis (1966) in his study of the perennial species of *Claytonia* recognizes it as a variety of *C. lanceolata*.

Claytonia lanceolata was originally described by Pursh (1814) from a collection of plants made by Meriwether Lewis on the Lewis and Clark Expedition (1806-07). The type locality is "on the Rocky Mountains," and the collection was made in June. The species is based on the following description: "foliis lanceolatis; caulinis ovatis sessilibus, racemo solitario elongato, calycis brevibus obtusissimis, petalis cuneatis bifidis, radice tuberosa."

Rydberg (1904) described *C. rosea* on the basis of three collections from Colorado, the type locality La Veta. The species was mentioned as occurring between 5,000 and 7,000 ft, and characterized by the following description:

"Scape about 1 dm high, slender, from a small corm 10-15 mm in diameter; basal leaves rare, long-petioled, blade 1-2 cm long, spatulate; stem leaves linear or narrowly linear-lanceolate, sessile, 2-5 cm long, 1 ribbed or faintly 3 ribbed, acute, rather fleshy; sepals rounded ovate, rounded at apex, about 5 mm long, half as long as the pink obovate petals; inflorescence 5-10 flowered, short, little exceeding the leaves, bractlets lanceolate; capsule shorter than sepals, seeds 2 mm long, black and very glossy."

GROSS MORPHOLOGY AND DISTRIBUTION

Part of the confusion which has existed in the application of the names *C. rosea* and *C. lanceolata* might be attributed to incompleteness of the original descriptions. Both species were based on seemingly atypical individuals. For example,

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²Based on a dissertation submitted by the first author in partial fulfillment of the requirements for the degree of Master of Science at the University of Colorado.

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C. lanceolata is depicted in the illustration accompanying the original description with multiple basal leaves. Corms of *C. lanceolata* typically produce a basal rosette of leaves until they have reached a size sufficient for the production of flowering stems. Thereafter, flowering stems occur but basal leaves do not (Fig. 2). Conversely, flowering corms of *C. rosea* typically produce basal leaves, but they were noted as rare in the original description. Normally the number of basal leaves is two (Fig. 1), but this may be a function of the age of corms. From none (noted in a single population) to as many as ten basal leaves per corm have been observed in *C. rosea*.

Another inconsistency arising in current treatments concerns the petal apex (Fig. 1-2). *Claytonia lanceolata* generally has emarginate-retuse petals while those of *C. rosea* have rounded to acute apices. In the Rocky Mountains this character has been neglected, and the petals of *C. lanceolata* (s. l.) are described as "rounded to emarginate" (Harrington, 1954). In areas outside the range of *C. rosea*, such as the Pacific Coast and Idaho, the petals of *C. lanceolata* are usually described as emarginate to retuse (Abrams, 1944; Davis, 1952; Munz, 1959). Apparently, the morphological concept of *C. lanceolata* has become expanded to include *C. rosea* in areas where they occur together, but where *C. lanceolata* is the only species present the species description mentions only retuse or emarginate petal apices.

These two species are clearly distinguishable on a gross morphological basis. *Claytonia rosea* possesses rounded to acute petal apices, basal leaves ranging from linear to lanceolate and usually linear cauline leaves. *Claytonia lanceolata* is characterized by emarginate petals, absence of basal leaves, and elliptical to ovate cauline leaves. These characters, however, are subject to some variation. A population of *C. rosea* without basal leaves was discovered near Boulder, Colorado, but the petals are entire and cauline leaves are linear. In the Yellowstone area of Wyoming the cauline leaves of *C. lanceolata* are frequently more narrow than is typical. The petal is emarginate, however, and there are no basal leaves. Thus, a combination of any two of these characters, i.e. petal apices, cauline and basal leaves, will distinguish either taxon.

The geographical distribution of *C. rosea* is known to include the southern Rocky Mountains of south-central Wyoming and Colorado, western New Mexico and parts of northern Arizona. It may, however, also occur as far north as southern Montana. *Claytonia lanceolata* is more widely distributed, occurring from southern Canada to northern California on the Pacific Coast and to southern Colorado in the Rocky Mountains. The species are presently known to be geographically sympatric only in the southeastern Rocky Mountains, but even here they are usually altitudinally and ecologically isolated. Because *C. lanceolata* is widely distributed and highly variable, there appears to have been a tendency to overlook closely related geographically sympatric species, such as *C. rosea*.

CYTOLOGY

Methods—Young floral buds, root tips and leaves were fixed in a 3:1 solution of acid alcohol. Storage was in 70% ETOH. The aceto-carmin squash technique

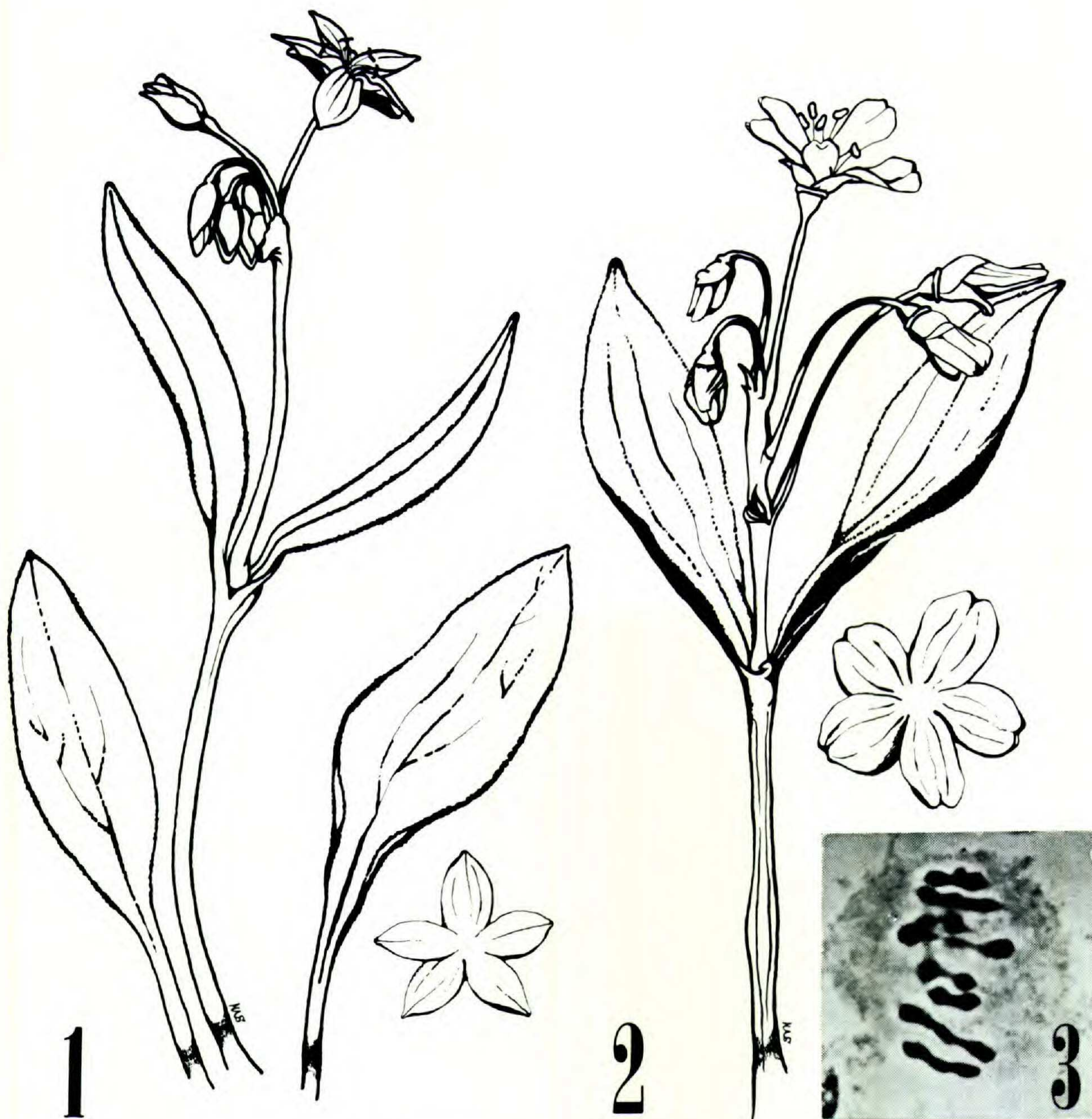


Fig. 1-3. Illustrations of *Claytonia*. Fig. 1. *C. rosea*. Fig. 2. *C. lanceolata*. Fig. 3. Meiotic MI in *C. rosea*. \times ca 1400.

was used to study microsporogenesis; for mitosis the Feulgen method was employed. Hydrolysis was in 1 N HCl at 60° C for 6 minutes. Somatic material was also killed and fixed directly in acid alcohol without pre-treatment.

We experienced significant difficulties obtaining floral buds undergoing meiosis in *C. lanceolata*. Apparently this species undergoes meiosis beneath deep snowbanks sometime during the winter or early spring (a topic discussed later). In contrast *C. rosea* is not associated with such melting snowbanks; consequently floral buds are easily obtainable shortly after emergence of the plants in early spring or late winter. Fortuitously, we discovered that corms of *C. lanceolata* maintained under refrigeration will produce immature plants from which some dividing PMC's were obtained. The chromosome numbers reported for *C. lanceolata* appeared reason-

ably clear, but the paucity of dividing cells in a given tissue generally prevented adequate verification of given numbers.

Voucher specimens for all phases of the study are deposited in the herbaria of the University of Colorado and the University of Utah.

Results and discussion—Cytologically, *C. rosea* appears to be a stable diploid species with a base number of $n=8$ (Table 1, Fig. 3). This number agrees with reports by Rothwell & Heiser (1951), Davis & Bowmer (1966) and Lewis (1966). With the exception of some PMC's which appeared to have trivalent and univalent formation, there was no significant deviation from the base number in the populations we examined. Because long polyploid-aneuploid series of chromosome numbers have been reported for the closely related *C. virginica* L. of the eastern United States (Rothwell, 1959, 1965; Lewis, 1962), several populations of *C. rosea* were sampled in depth for such variations in chromosome numbers; however, none were noted.

In *C. lanceolata*, however, we have not been able to resolve a definite base number. Our data (Table 1) show variation in both meiotic and mitotic chromosome numbers for *C. lanceolata*. This concurs with the results of Davis & Bowmer, who worked exclusively with meiotic material. However, where the two species are geographically sympatric, only polyploid numbers are presently known in *C. lanceolata*, but beyond the western range of *C. rosea* diploid numbers ($n=8$) are also known in *C. lanceolata*: this likewise agrees with Davis & Bowmer, except that they report $n=8$ for *C. lanceolata* from Mesa Verde National Park, Colorado, where we found only diploid *C. rosea*.

An earlier report of $n=8$ in *C. lanceolata* (Wiens & Halleck, 1962) should be disregarded; the plants from which the chromosome numbers were determined actually were *C. rosea*.

The chromosome numbers of related species are of interest in order to determine a base number for the group. *Claytonia megarrhiza* (A. Gray) Parry is confined to the alpine areas of the Rocky Mountain system. Wiens & Halleck indicated a gametic number of between 16 and 18 for this species. Subsequent analysis of populations on Mt. Evans, Colorado, were $n=16$, which agrees with the report by Davis & Bowmer. Rothwell & Heiser (1951) reported $n=8$ in *C. caroliniana* Michx. and Johnson & Packer (1963) found $2n=16$ in the Alaskan species, *C. tuberosa* Pall. ex Willd. Sokolovskaya (in Cave, 1964) found $2n=30-32$ in *acutifolia* Pall. from the Kamchatkan peninsula. Rothwell (1959, 1965) indicates 8 as a modal number in his studies on *C. virginica*, although Lewis (1962) found $n=7$ as the mode in his observations of this species in Texas. In view of the recurrence of 8 in a number of diverse taxa, it appears at this time to emerge as a base number for the group.

BARRIERS TO GENE EXCHANGE

In the region of the Colorado Front Range, at least three factors appear to prevent hybridization between *C. rosea* and *C. lanceolata*. These include (1) ecological, (2) seasonal, and (3) chromosomal mechanisms.

Table 1. Chromosome numbers in *Claytonia rosea* and *C. lanceolata*.

<i>C. rosea</i>		<i>C. lanceolata</i>	
Chrom. no.	Collection data	Chrom. no.	Collection data
$n=8$	Flagstaff Mtn, Boulder Co, Colo. ^a	$n=22$	Nr St. Vrain Glacier, Boulder Co, Colo. <i>H</i> 40
$n=8$	Boulder Canyon, Boulder Co, Colo. <i>H</i> 6.	$n=ca\ 27, ca\ 37, ca\ 38, ca\ 42, ca\ 45; 2n=ca\ 37, ca\ 52$	Nr Pawnee Basin Campground, Grand Co, Colo. <i>H</i> 101.
$n=8$	Left Hand Canyon, Boulder Co, Colo. <i>W</i> 2831.	$n=22$	Togwotee Pass, Jeffer- son Co, Wyo. <i>H</i> 100.
$n=8$	Magnolia Hill, Boulder Co, Colo. ^b	$2n=32, 36$	Nr Kamas, Summit Co, Utah. <i>D</i> 5020.
$n=8$	Lookout Mtn, Jefferson Co, Colo. ^c	$2n=24$	Pole Canyon, U t a h Co, Utah. <i>D</i> 5021.
$n=8$	Mesa Verde Ntl Park, Colo. ^d	$2n=16$	North Bench, Salt Lake City, Salt Lake Co, Utah. <i>W</i> 3037.
$n=8, 2n=16$	Nr Mogollon, Catron Co, N. Mex. ^e		
$2n=16$	Oak Creek Canyon, Coconino Co, Ariz. <i>CR</i> 3.		

^a 24 counts representing 16 populations: *H* 12, 20, 22, 25, 26, 30, 33, 35, 42-45, 48, 50 *a-g*, *T*-2. Some possible univalent and trivalent formation.

^b 5 counts. *H* 55 *a-e*.

^c 5 counts. *H* 51 *a-c*, *H* 52 *a-b*.

^d 4 counts. *H* 60 *a-b*, *H* 61 *a-b*.

^e 6 counts. *W* 3005.

Ecological—*Claytonia rosea* is a species of the Rocky Mountain Montane Forest Association, occurring most frequently between the altitudes of 5,000 and 7,000 ft. Often it grows beneath stands of ponderosa pine (the dominant tree of this association) and around the small meadows typical of the region. *Claytonia rosea* usually appears several weeks after the snow melts from an area, and is one of the first spring flowers of the region.

However, *C. lanceolata* occurs in the regions where they are sympatric; the Rocky Mountain Subalpine Forest Association dominated by dense stands of spruce-fir, where it is most common between 10,000 and 11,000 ft and associated with melting snowbanks. Our observations suggest that in this environment vegetative and reproductive development occurs in this species during the winter or early spring while the plant is deeply covered with snow. Attempts to obtain young

plants which had not yet undergone meiosis by digging through snowbanks three to four feet deep proved unsuccessful. Active growth and reproductive development, including meiosis and flower formation, was observed in a few corms refrigerated at approximately 37° F through the winter. The corms broke dormancy about the first of January and while growing in nearly total darkness produced roots, stems, leaves and flowers. Dr. John Marr of the Institute of Arctic and Alpine Research at the University of Colorado states that soil temperatures beneath deep snowbanks remain above freezing through the winter. Apparently the laboratory conditions roughly simulated those which the plants encounter in nature.

The snowbank ecology described for *C. lanceolata* is an interesting phenomenon. For example, the stage of development of the plants can be predicted roughly by its distance from the edge of the receding snowbank. At the margin of the snowbank etiolated but fairly mature plants can be observed. Continuing outward one can find the plants in anthesis, fruits, and moribund at a prescribed distance from the edge of the snowmass. In regions beyond the range of *C. rosea*, however, *C. lanceolata* may also be found associated with other vegetation types. For example, in the Wasatch Mountains of Utah *C. lanceolata* is continuously distributed from the Scrub Oak Community along the lower foothills where it blooms in the early spring, to the Spruce-Fir Community, where it flowers as late as July. However, in these situations it still maintains its association with melting snowbanks or moist areas.

Seasonal—*Claytonia rosea* usually appears several weeks after the snow cover has melted. The time of emergence naturally varies from year to year; however, at lower elevations along the Colorado Front Range they usually appear between late February and early March. The species flowers into May at the higher elevations where the snow cover remains longer. Populations probably do not remain in flower for more than two or three weeks, and by the end of May it is usually difficult to find individuals of this species blooming at any elevation.

Claytonia lanceolata on the other hand, does not begin to flower until the large snow accumulations begin to melt under the Spruce-Fir Forests, toward the last of May or the first part of June. The species will usually continue to bloom as long as it takes for the snow accumulation areas to melt. This varies with the amount of snow, but is usually complete toward the end of July.

Approximately two to four weeks usually separate the extreme flowering periods for both species. This phenomenon is, of course, a corollary to the fact that the spring melt-out is related to altitude. Seasonal barriers to crossing, therefore, reinforce the effectiveness of ecological isolation between the two species.

Chromosomal—Theoretically, taxa with disparities in chromosome numbers are not expected to produce fully fertile progeny. The individuals of *C. lanceolata* which we have examined cytologically showed that in most cases this species is polyploid where it is sympatric with *C. rosea* (Table 1). These data suggest that barriers to hybridization should characterize these species, but no actual crosses have been made. No evidence suggesting natural hybridization has been encountered.

SUMMARY AND CONCLUSIONS

Claytonia rosea is distinguished from the related species, *C. lanceolata* with which it has been confused on the basis of the following criteria:

GROSS MORPHOLOGY—*Claytonia rosea* is characterized by possessing basal leaves, whereas *C. lanceolata* has none. The cauline leaves of *C. rosea* are linear to linear-lanceolate. The cauline leaves of *C. lanceolata* are elliptical-lanceolate to ovate. The petals apices of *C. rosea* are usually acute, while those of *C. lanceolata* are emarginate. While these characters show a normal range of variation, combinations of these characters will consistently distinguish the two species.

KARYOLOGY—*Claytonia rosea* is a diploid species with a consistent chromosome number of $n=8$. *Claytonia lanceolata*, appears to have variable chromosome numbers, and might possibly have a genetic system similar to the eastern spring beauty, *C. virginica*. In areas where the two species are sympatric *C. lanceolata* is polyploid, but diploid populations of $n=8$ are known in this species beyond the range of *C. rosea*. The species are apparently characterized by distinctive chromosomal systems.

ECOLOGY—*Claytonia rosea* is a species occurring primarily in the Rocky Mountain Montane Forests, in meadows, or beneath stands of Ponderosa Pine, and blooms after the snow has melted. Conversely, *C. lanceolata* generally occurs in the Rocky Mountain Subalpine Forest, at least where it is sympatric with *C. rosea*. However, in areas beyond the range of *C. rosea* it may also occur in other associations. Regardless of the plant community, however, *C. lanceolata* is generally associated with melting snowbanks. Where the species are geographically sympatric, anthesis in the two species generally does not overlap.

If Davis (1966) uses variety in the classical sense, viz. for geographically restricted and morphologically definable population systems typically merging with other similar subgroups of the species, then, the available evidence precludes the application of variety to *C. rosea*. The existence of ample, consistent character differences between the two taxa suggest significant evolutionary divergence. Furthermore, they are geographically sympatric, although they are usually not found in close association. When the two taxa do occur near one another, there is absolutely no evidence of hybridization, and the species maintain completely their genetic integrities.

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